

## **Leg-length in relation to selected ballet performance indicators**

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## **Abstract**

**Introduction:** It is unclear whether the modern ballet body stereotype of long limbs is advantageous in dance performance. Therefore, we investigated the relationship between leg-length and selected dance movements representative of power, dexterity and range of motion, in ballet dancers at different competence levels.

**Methods:** The total of 10 recreational, 24 vocational and 10 professional ballerinas volunteered. They were subjected to: a) lower limb length measurements, b) power tests; vertical jump -*sautés* and unilateral countermovement jump-*temps levé*, c) dexterity tests; *tendus* and *double battement frappés*, and d) flexibility tests; lateral active and passive-*développé à la seconde*.

**Results:** For power, regression analyses revealed negative leg-length relationships in recreational (*sautés*–  $p<0.05$ ; *Temps levé* -  $p<0.05$ ) and positive leg-length relationships in vocational (*sautés* –  $p<0.05$ ) dancers. We also found negative relationships between leg-length and dexterity in the vocational group (*tendus*–  $p<0.05$ ; *double battement frappés* –  $p<0.05$ ). No significant predictions of leg-length on power, dexterity and range of motion were found in professional dancers. Multiple comparisons revealed significant differences between groups only for dexterity ( $p<0.05$ ) and range of motion ( $p<0.05$ ).

**Conclusion:** Based on selected movements representative of power, dexterity and range of motion, the present data indicate that lower limb length is not a determinative criterion for ballet success. Further studies should investigate whether body stereotypes, such as long limbs, are linked to dance injuries.

**Key words:** Anthropometry, ballet, power, dexterity, range of motion

## **Introduction**

Ballet is an activity with specific rules regarding the position of arms, feet and body. It is also an activity linked to high injury rates [1-3] and other medical conditions [4] which can be partly explained by the relatively poor fitness levels [5-8] and/or overwork [9, 10]. Despite of that, many sections of the dance world share the unfounded view that supplementary fitness training away from the dance studios would harm certain aesthetic elements [11, 12]. Yet, the results of a dance-only approach to dance training can be surprising. For instance, although female dancers are stronger than active non-dancers, the former demonstrate lower jumps than the latter [13].

Ballet is primarily determined by musical rhythm and movement quality rather than by rules of nature such as force, inertia and gravity [13]. Ballerinas embody ethereal, floating and fast movements, which constitute the basis of their art. However, although ballet body stereotype necessitates long limbs, medium torso and long neck [14-16] anecdotal evidence supports the notion that virtuosic ballet roles have been performed by dancers with relatively longer torso and shorter legs allowing them to move their limbs faster. Nevertheless, a study on 106 dancers has shown the beneficial role of leg length in jumping performance [16]. Interestingly, the same study also revealed a negative association between lower extremity limb length and flexibility. Conflicting data also exist in other sports. In rhythmic gymnastics, for instance, studies have demonstrated both significant [17] and non-significant [18] relationships between anthropometric factors and performance, while others have shown that long legs do not provide substantial biomechanical advantage [19]. Given the contradicting information available thus far, the aim of the present study was to investigate the relationships between leg-length and selected ballet performance indicators representative of power, dexterity and range of motion, in a sample of female ballet dancers at different competence levels.

## **Methodology**

### **Participants**

The total of 44 female dancers volunteered. They formed three different groups based on their experience. The first group comprised recreational ballet dancers, members of a youth ballet company (n=10), with an average of 2-3 ballet classes and 2-3 hours of rehearsals per week. The next included vocational ballet students (n=24) engaged in 90

min ballet classes and 90 min contemporary dance daily. The third group involved professional dancers from an elite classical ballet company (n=10); they participated in 90 min ballet classes and 1-3 hours of rehearsals daily. The inclusion criteria included: a) free of injury for at least three months [16], and b) no extra fitness training or sport activity for at least three months [16]. The study was approved by the Institutional Ethics committee (ref:113270) All volunteers provided a signed informed consent.

## **Data Collection**

We investigated the relationships between leg length and selected dance movements representative of power, dexterity and range of motion, in ballet dancers at different ability levels. All tests were adjusted to simulate ballet movements. Power was assessed via vertical jump (VJ) in the form of a) *sauté* in 1st position and b) *temps levé* in one foot (UCJ –hop step). Dexterity was tested through a) *tendus* and b) *double battement frappés*, whereas range of motion was verified laterally (both passively and actively), in the form of *developpé à la seconde*. All procedures were described and explained to participants and there was a familiarization period. Tests were conducted at the end of the barre during the ballet class with rest intervals of 2-3 minutes. Since static stretching was integrated in the flexibility protocol, power and dexterity tests preceded the flexibility test as previously suggested [16, 20-22]. Measurements were taken from the participants' preference leg [23], which was determined as previously described [24].

## **Anthropometric Measurements**

Standing height was obtained by a Seca Stadiometer 208 with shoes off, and leg length with the use of an anthropometric tape measuring the distance between the greater trochanter and the lateral malleolus [16]. Weight was obtained by means of a scale.

## **Power Tests**

### **a) Vertical Jump (VJ)- *Sauté* in 1st Position**

The Vertical jump test was employed using a portable power matt (Bosco Ergojump). Participants were asked to perform a countermovement jump taken from 1st position classical ballet with no free hands (*sauté* in first position, arms *bras bas*) and *plié* before every jump. The torso was placed in an upright position throughout the test. The participant completed 3 bilateral countermovement jumps with a 30- second rest period in between attempts; the highest score was recorded.

### **b) Unilateral Countermovement Jump – (UCJ). Temps Levé**

The Bosco Ergojump was also used for measuring UCJ height. Participants were asked to perform *Temps levé* with their preference leg starting with *plié*, while the other leg was placed in *coupé derrière* position. Hands were in *bras bas* position with torso in an upright position. Each participant completed 3 *temps levé* with a 30-second rest between attempts. The highest score was recorded for further analyses.

## **Dexterity Tests**

### **a) *Battement Tendus* in 15-second**

Dancers were asked to perform *battement tendus à la seconde* taken from 1st position with their preference leg within a 15-second period time. Two experienced observers recorded the number of *tendus* performed during the set period (15 sec). Ballet methodology describes *battement tendu à la seconde* as a sliding movement starting from close position (in this case from 1st position-turn out) and finishes when the working leg and its toes are fully extended to the side, with toes touching the floor. Then, the working leg slides back closing into 1st position.

### **b) *Double battement Frappés* in 15-second**

Participants were asked to perform *Double Battement Frappés* starting from an open position – *à la seconde* (leg is extended to the side with toes just above the floor). They were allowed to use their preference leg while two experienced observers recorded the number of *double battement Frappés* completed within 15 seconds. Although the working leg is placed at an open position, movement occurs mainly at the knee area. The foot of the extended leg is drawn back striking behind and in front of the ankle of the supporting leg, and is then extended out again in the straight position. The foot remains at the *coup-de-pied* position during the exercise.

## **Flexibility Tests**

### **a) Active and passive range of motion**

Range of motion was tested both actively (aROM) and passively (pROM), in the form of *Développé à la seconde*. For an aROM movement begins with the flexion at the knee and the hip area, external rotation and abduction of the working leg, whereas the foot is fully stretched into *coup de pied* position. Leg draws upward, towards the knee of the working leg and then is extended to the side. For pROM, participants were asked to

perform a static stretch by grasping the ankle of their working leg and stretching it to the side, up to their physical ability [16]. Positions were held for 3 seconds. Each participant performed three attempts for aROM and pROM, respectively, which were photographically captured. The greatest aROM and pROM was recorded; the mean difference of each group for active.

## Statistical Analyses

Simple regression analyses were performed to determine whether lower limb length could predict power, dexterity and range of motion in the three studied groups. Multiple comparisons were used to identify changes any trends between group variables. Alpha level of significance was set at  $p < 0.05$ .

## Results

Anthropometric data together with descriptive data from the power, dexterity and ROM test appear in Tables 1 and 2, respectively. Simple regression analysis in recreational dancers revealed negative relationships for lower limb length only on power,  $R^2 = .52$ ,  $F(1,8) = 8.76$ ,  $p < .05$ ,  $\beta = -.72$ , ( $t = -2.96$ ,  $p < .05$ )- **VJ-sautés**;  $R^2 = .51$ ,  $F(1,8) = 8.19$ ,  $p < .05$ ,  $\beta = -.71$ , ( $t = -2.86$ ,  $p < .05$ )-**UCJ-Temps levé**. For vocational dancers we observed positive relationship only on power and more specifically in **VJ-sautés**  $R^2 = .21$ ,  $F(1,22) = 5.86$ ,  $p < .05$ ,  $\beta = .46$ , ( $t = 2.42$ ,  $p < .05$ ) and negative relationships for lower limb length on dexterity  $R^2 = .19$ ,  $F(1,22) = 5.02$ ,  $p < .05$ ,  $\beta = -.43$ , ( $t = -2.24$ ,  $p < .05$ )- *tendus*;  $R^2 = .21$ ,  $F(1,22) = 6.00$ ,  $p < .05$ ,  $\beta = -.46$ , ( $t = -2.45$ ,  $p < .05$ ) *double battement frappés*. Finally, there were no significant predictions of lower limb length on power, dexterity and range of motion for professional dancers.

**Table 1:** Anthropometric data

Groups	Age (yrs)	Height (cm)	Mass (kg)	Leg length (cm)
Recreational	16 ± 1.8	164 ± 5.1	49.5 ± 4.6	79.2 ± 4.2
Vocational	20 ± 1.9	164.5 ± 6.9	54.2 ± 5.4	80.9 ± 4.0
Professionals	36 ± 9.5	167.4 ± 5.7	51.2 ± 5.5	80.5 ± 4.7

**Table 2:** Descriptive data from the power, dexterity and ROM tests

Groups	<b>Tendus (15s)</b>	<b>Double Battement Frappés (15s)</b>	<b>Sautés (VJ) (cm)</b>	<b>Temps levé(UCMJ) (cm)</b>	<b>aROM (cm)</b>	<b>pROM (cm)</b>
Recreational	30.7±1.7	20.5±2.1	27.7±3.8	14.4±3.5	112.5±11.4	148± 13.8
Vocational	35.0±3.6	21.8±2.7	25.1±3.7	14.0±1.9	118.1±14.7	153.8±15.6
Professional	36.3±3.3	24.6±1.8	28.1±4.0	16.4±4.3	144.6±13.8	167.3±11.3

Multiple comparisons revealed significant differences between groups in dexterity and flexibility (ROM). In particular, for *tendus* there were between: a) recreationals and vocationals ( $p<0.003$ ), and b) recreationals and professionals ( $p<0.001$ ). For *double battement frappés* differences were between: a) professionals and recreationals ( $p<0.001$ ), and b) professionals and vocationals ( $p<0.006$ ). Furthermore, for aROM, differences were found between professionals and recreationals ( $p<0.001$ ), whereas for pROM, differences were found between: a) professionals and recreationals ( $p<0.002$ ), and b) professionals and vocationals ( $p<0.010$ ).

## Discussion

The aim of the present study was to investigate the relationships between leg-length and selected dance movements representative of power, dexterity and range of motion, in a sample of female ballet dancers ranging from recreational to professional standards. We found no clear evidence that leg-length plays a determinative role for success in ballet. For power, for example, we found negative leg-length relationships in recreational, positive in vocational, and no relationships in professional dancers.

Long levers are advantageous only when the associated muscles are strong enough to bring about their maximum function. A shorter leg can cope with inertia better than a longer one [16], as the later requires greater muscular strength in order to move. The significance of torso-to-legs ratio should also be stressed, as it determines the speed at which muscles can activate body levers [25], as well as the angle of the legs bent in the knee joints at the hip area [26]. The positive power found for the vocational dancers is in line with what one might expect from young people involved engaged in demanding training programs. However, the fact that leg-length revealed no relationships for professional in jump height (power), could likewise be attributed to the fact that dancers

learn to perform in a controlled manner, following very strict and clear body alignments, which focuses in the aesthetic part of the action rather than its physical component [12].

The negative link between leg-length and dexterity found in the current vocational dancers, was probably due to the fact that they were unable to efficiently control their movements due to a combination of factors, such as low level of expertise, increased inertia and/or lack of optimal fitness [4, 5, 8, 29, 30]. It should be noted that dexterity and development of motor skills are related to length of ballet training [16, 31], which is more likely to occur in professional dancers and that dexterity is not associated to strength given their documented lack of strength training [6, 11, 27, 28]. It is the repetition of standardized ballet movements that may bring about the internalization of the movement pattern for the purposes of creating a motor schema and a special adaptation [31, 32].

The current data revealed no relationships between leg-length and either aROM or pROM in ballet dancers at all three competence levels. This may partly be explained by the fact that ROM exercises are always part of dance auditions, which make flexibility an integral characteristic in most dancers. Besides, ROM is closely associated with hereditary factors [7, 25]. The inability of the less experienced dancers to keep the height of the leg is probably due to lack of strength at the hip area [33]. Given that dancers do not treat strength training as one of their performance ingredients may account for the aforementioned findings [6, 11, 28, 34]. It should be added here that, contrary to the common belief that increased flexibility levels protect against sport injury, this has not been confirmed in elite dancers [35].

Although no significant leg-length relationships were found in most of the studied performance parameters, a trend has been observed whereby the higher the expertise level (from recreational, vocational to professional dancers), the greater the power, dexterity and range of motion. This finding suggests that performance levels are closely linked to length of ballet training rather than influenced by body characteristics [18, 19].

It is reasonable to assume that the present results may have been influenced by methodological limitations such as the relatively small number of participants and the lack of data on sitting height-to-leg length ratios which determine the speed at which muscles can activate body levers [25].



## Conclusions

Within the current limitations, the present data indicated that leg length does not seem to play a determinative role for success in the ballet movements studied herein. Further studies should investigate whether specific body stereotypes used for aesthetic purposes, such as long limbs, are linked to frequently reported dance injuries.

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